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Potential Predictors of Target Acquisition Performance by Gunners: A Literature Review

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for

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For this research note, a review of the literature was conducted to determine the feasibility of selecting and/or training gunners for target acquisition skills. Of particular interest was literature which might pertain to the Advanced Antiarmor Weapons System - Medium (AAWS-M). It was recommended that any trial selection battery should include measures of visual acuity, color vision, contrast sensitivity, dark focus, peripheral vision and perceptual style. It was concluded that training was essential for developing identification skills, and would probably improve detection skills, as well.

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POTENTIAL PREDICTORS OF TARGET ACQUISITION PERFORMANCE BY GUNNERS:
A LITERATURE REVIEW

Executive Summary

Requirement:

This research was undertaken in response to a request from the Science Advisor, Office of the Deputy Chief of Staff for Operations and Plans, U.S. Army. It was part of a larger effort that was requested by the Vice Chief of Staff of the Army in early 1985. The primary objective of this literature survey was to provide information which would assist in determining: (a) whether potential predictors of target acquisition performance by gunners could be identified, and (b) whether it would be feasible to use these predictors to assist in selecting and training as gunners those personnel with the greatest predicted abilities to detect, recognize, and identify potential vehicular targets at tactical ranges. Both daylight optics and FLIR were of concern. Of particular interest was literature which might be pertinent to the Advanced Antiarmor Weapons System-Medium (AAWS-M).

Procedure:

Computer searches were run through the Defense Technical Information Center and a civilian data base called DIALOG. Approximately 21,000 documents related to target detection and identification were located. This number was greatly reduced by adding descriptors related to personnel selection and training to the search strategy. Abstracts for these were screened for actual relevance, and the relevant documents were obtained. Other documents were obtained from colleagues working in the same general technical areas.

Findings:

The findings of the studies reviewed were not entirely consistent due to differences in targets, geographical areas, experimental factors, and observers. Nevertheless, it appeared that there were some measures with good potential for selecting AAWS-M gunners for detection and identification skills.

Visual tests currently employed routinely by the Army which seemed promising were tests of static visual acuity and color vision. Tests not currently used but recommended for an experimental battery are tests of constrast sensitivity, dark focus, refractive status, and peripheral vision.

Measures of field dependence-independence were the only paper-and-pencil type tests that showed promise, so it was recommended that one such test be included in the battery.

Results of research on the effectiveness of training for target detection skills were mixed. Nevertheless, it was concluded that carefully tailored training would improve the target detection skills of AAWS-M gunners regardless of the feasibility of using gunner selection procedures. Training for target identification skills was concluded to have a positive impact, although learning rates were shown to vary considerably among individuals.

Utilization of Findings:

The results of this research are being used to assist in determining potential predictors of target acquisition performance by gunners, and whether it is feasible to use such predictors to select and train gunners. A particular emphasis is being placed upon the selection and training of gunners for the projected AAWS-M.

Contents

POTENTIAL PREDICTORS OF TARGET ACQUISITION PERFORMANCE BY GUNNERS: A LITERATURE REVIEW

OBJECTIVE

The primary objective of this research was to provide information that would assist in determing whether:

(a)   potential predictors of target acquisition performance by gunners could be identified, and

(b)   it would be feasible to use these predictors to assist in selecting and training as gunners those personnel with the greatest predicted abilities to detect, recognize, and identify potential vehicular targets at tactical ranges.   Of particular interest was literature which might be pertinent to the Advanaced Antiarmor Weapons System-Medium (AAWS-M).

While looking for answers to these questions, it was decided also to take note of any work suggesting other aptitudes, abilities or personal characteristics that might be useful in selecting personnel for the operation of a man-portable missile system such as the AAWS-M.

BACKGROUND

Advances in technology have resulted in weapons systems with ever increasing range, accuracy and lethality.   However, comparable advances in target detection and identification aids for the soldier on the battlefield have not been made.   Armor and infantry personnel must still rely almost entirely on their eyes to detect and identify potential targets. These tasks have, of course, become more difficult as the kill range of their weapons has increased.

Several recent events have strongly indicated that the detection and identification skills of the typical soldier are considerably poorer than believed. The need to improve these skills has been recognized at the highest levels of the Army. During the late spring of 1985, the Vice Chief of Staff of the Army requested that the possibilities of either selecting and/or training gunners for target detection and identification skills be examined. The request was specific to the Advanced Antiarmor Weapons System-Medium (AAWS-M), and was based upon the desire to improve soldier performance of these skills by improved selection procedures of gunners.   A meeting to discuss this request and initiate preparation of a response was convened by the Science Advisor, Office of the Deputy Chief of Staff for Operations and Plans, in early June 1985. Personnel from a variety of agencies in both the user and research communities were in attendance. The literature survey reported here was prepared as part of the response of the Army Research Institute for the Behavioral and Social Sciences (ARI).

METHODOLOGY

A discussion of how the literature survey was conducted and the problems encountered is given in the following several paragraphs. This is done in order to present a perspective on why the relevant research is as meager as it is, and why it was difficult to interpret the findings that did evolve.

First of all, computer searches were run through both the Defense Technical Information Center, or DTIC, and DIALOG, a civilian data base. The DTIC search located documents that were identified by any one of the words Target detection, Target recognition, Target identification, Target acquisition, or Target signatures. Over 16,000 documents were identified. In addition, another 5,000 plus were found in the DIALOG search. One would think that among these approximately 21,000 individual documents there should be ample material related to personnel selection and training. However, this did not prove to be the case. When additional qualifiers related to personal characteristics or training were added to the search strategy, the number of available documents was reduced to only a few hundred. By reading abstracts for these, a significant portion of them were further eliminated. A large number of these were reports of some very excellent work. Unfortunately, they were aimed at development of computer models, and performance measures were based on the "average" observer. Even when individual variability in performance was reported, no attempt was made to correlate these data with individual differences in aptitudes, experience, or visual characteristics. A number of the remaining reports were unobtainable for a variety of different reasons. Nevertheless, approximately 300 documents were acquired and examined in enough detail to determine their relevancy. Several of these were reviews or annotated bibliographies which covered considerable ground and provided clues to other relevant documents. Many of those acquired proved to be laboratory studies and it was difficult to judge how well their conclusions would generalize to the "real world." Many of these were eliminated from further consideration on the basis of professional judgment. For example, there was an unwillingness to conclude that a college student searching for a small black dot on a television screen was necessarily equivalent to a soldier searching for a tank in a wooded area.

RESULTS

General

Once having distilled the literature, other considerations remained. As mentioned earlier, the findings concerning target detection and identification performance and the efficacy of training were far from consistent. In trying to find reasons why, an attempt was made to take a comparative look at the studies reporting opposite results, especially those conducted in the field. It was found that they were virtually impossible to compare. Table 1 points out some of the major differences among studies reported.

Target characteristics were extremely varied with respect to type, density, degree of exposure, size, and movement. Locales varied from desert to forest. Weather and visibility conditions were often not even reported. Experimental conditions were tailored to the purposes of the studies, and highly variable. Terms were defined differently.

Table 1

Differences Among Studies

Targets

       Different target objects
       Different target densities
       Different number of target types in array
       Targets stationary or targets moving
       Different degrees of concealment
       Different exposure times

Geography

       Varied terrain (from desert to forest)
       Varied atmospheric/weather conditions not reported

Experimental Factors

       Different definitions of detection and identification
       Different criteria of success
       Different observer locations (air/ground)
       Observer moving or observer stationary
       Varied observer aids (none, optical, electro-optical)
       Varied degrees of briefing
       Varied sizes of assigned search sectors
       Varied conditions of early warning

Observers

       Varied ages
       Varied aptitudes
       Varied visual characteristics
       Varied occupational specialties
       Varied experience
       Varied levels of training not reported

"Identification," for example, was sometimes defined as being able to determine whether the target was a member of a particular class of objects such as a tank, a truck, or a missile launcher. In other cases, the respondent had to name the target, like calling it an M60 or an M113. Criteria of successful performance also varied. In some studies observers were told that range to the target was the critical performance variable.

Detections were made at long range, but a number of false detections were also made. In other studies accuracy was the stated criterion. Targets were not reported until they were much closer, but fewer false targets were reported. The biggest problem, however, lay in the incomplete reporting of personnel characteristics. For example, a researcher might report a correlation, or the lack thereof, between some visual characteristic and detection performance, but fail to report the range or any other individual characteristics that might be related to performance. The attempt to determine the role of experience in target detection and identification performance has been particularly frustrating. Experience as a factor has been shown to run the gamut from very highly related to totally unrelated to performance. The probable reason for this is in the ways experience is reported. Most typically, it is reported as months in service, months in MOS, or number of flying hours. However, neither the recency nor the relevance of this experience to the target acquisition task is reported, nor is the amount and recency of any relevant training. In other words, it is impossible to determine whether many of these studies really evaluated the relationship between experience and target acquisition performance. In fact, in some instances, studies with promising titles were so poorly or incompletely reported that it was not possible to determine exactly what the experimenters did or what they found. So finally, after all the sorting, only a little more than 100 documents were found that bore directly on the questions the literature survey and analysis were trying to answer. Most of these were concerned with air-to-ground target detection and identification, some with ground-to-air, and some even with air-to-air. There appeared to be far less interest in ground-to-ground detection and identification. In selecting the final set of documents, it was assumed that personal characteristics which affect detection and identification performance in one situation would normally affect, at least to some degree, that performance in other situations.

Personnel Selection

Criterion Reliability

The first task was to determine whether there were actually any consistent individual differences in target detection and identification ability. Unless individuals performed consistently, there obviously would be no point in trying to select personnel for these aptitudes. Studies which kept track of individual performance over repeated measures were few, but fortunately, the findings were consistent (Self, 1979; Norlin, 1983; Valentine, 1973; Jones (personal communication), 1985). In one study of Navy pilots, a reliability coefficient of $r = .56$ was computed, a quite respectable number in a performance where observed intra-individual differences are as great as they are (Jones, 1985). Further evidence of the reliability of performance comes from studies in which detection range was predicted by other measures (e.g., Ginsburg, et al, 1983b). Therefore, it was concluded that the ability to detect and identify targets was durable, in which case it should be possible to develop selection measures for this ability. The potential of various kinds of selection measures is discussed in subsequent paragraphs.

Paper-and-Pencil and Laboratory Tests

First, the few studies that have attempted to validate paper-and-pencil or laboratory type selection tests were examined. The results have not been very encouraging. The British Airways Corporation (Seale, 1972) conducted two studies which looked at the relationships between the target detection performance of pilots and scores from Cattell's test of 16 personality factors. This test, usually referred to as the 16-PF, is a well known and much used personality test. No relationships were found between detection performance and any of the 16 personality measures. Kobrick and Fine (1975) found that introverts performed slightly better than extraverts on a detection range, but the relationship was too weak to be of practical significance.

Measures of field dependence-independence have also been tried. Presumably measures of this trait evaluate an individual's ability to extract or find a particular figure embedded or hidden in a background of other figures. Therefore, it would seem that high field independence scores should be predictive of target detection performance. This trait is typically measured by tests variously known as hidden figures tests or embedded figures tests. The results with this kind of test have been inconsistent. One study (Thornton, 1968) found that scores on the Embedded Figures Test were related to detection performance. Another found that scores were marginally but significantly related to scores on two tests of aircraft identification (Miller, 1985). Still another, which investigated several measures of field independence, found only one to be related to target detection performance in the field (Bucklin, 1971). Kobrick and Fine (1975) found "field independent" soldiers performed better in detecting a single infantryman in a wooded area. However, the two studies conducted by the British Airways Corporation found no relationships between target detection performance and scores on the Embedded Figures test. An ARI study (Ton & Kubala, 1978) found no relationship between a hidden figures test and Army pilots' ability to either handoff or receive target handoffs when the two observers were viewing the same target scene from different ranges and aspect angles. The Army Research Institute (ARI) Field Unit at Fort Bliss is currently analyzing data which will look at the predictive validity of the Embedded Figures test as well as a large number of other paper-and-pencil tests. The results may shed more light on the potential for these kinds of tests, at least for aircraft detection.

Figure 1 is a page from the Educational Testing Service Hidden Figures test. It may be that the ability to work with geometric shapes does not always transfer to real world situations. Nevertheless, since field independence scores were related to performance in some situations, it is felt that some measure of this trait should be included in any experimental test battery.

There are three studies which, although not necessarily concerned with either target detection or identification, examined the possibility of selecting personnel for man-portable missile systems similar to the AAWS-M, namely the Stinger and the TOW (Stewart, Christie, & Jacobs, 1974; Derhammer, et al, 1976; and Miller, 1985). A wide variety of paper-and-pencil and psychomotor measures were evaluated. The results were essentially negative. One study found that time in MOS was the only consistent predictor of Stinger gunner performance. One of the other studies found a small but consistent correlation with the General Maintenance (GM) score from the Army Classification Battery and TOW gunner performance. Even more discouraging was the finding in one case that performance in training was unrelated to live firing performance.

The prospects for selecting AAWS-M gunners with the typical paper-and-pencil and psychomotor tests are, therefore, not very promising.

HIDDEN FIGURES TEST — CF·1 (Rev.)

This is a test of your ability to tell which one of five simple figures can be found in a more complex pattern. At the top of each page in this test are five simple figures lettered A, B, C, D, and E. Beneath each row of figures is a page of patterns. Each pattern has a row of letters beneath it. Indicate your answer by putting an X through the letter of the figure which you find in the pattern.

NOTE: There is only one of these figures in each pattern, and this figure will always be right side up and exactly the same size as one of the five lettered figures.

Now try these 2 examples.
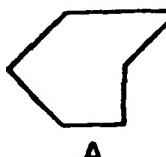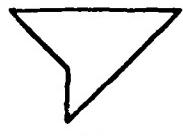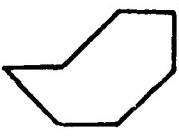
A   B   C   D   E

I   A B C D E   II   A B C D E

The figures below show how the figures are included in the problems. Figure A is in the first problem and figure D in the second.
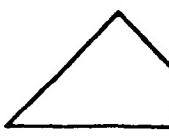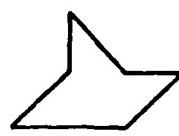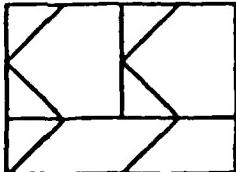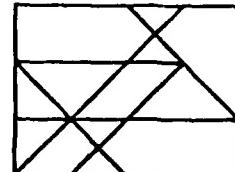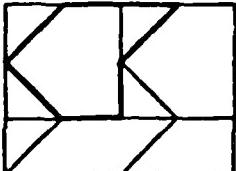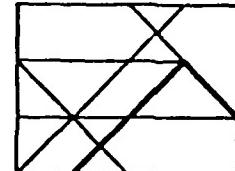
I   X B C D E   II   A B C X E

Your score on this test will be the number marked correctly minus a fraction of the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you are able to eliminate one or more of the answer choices as wrong.

You will have 12 minutes for each of the two parts of this test. Each part has 2 pages. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Figure 1. Sample items for the hidden figures test.

Visual Tests

It seems almost trivial to say that good vision is required for effective target detection and identification performance. The problem is in finding the right tests. There are a multitude of visual tests, but virtually no potential is indicated for most of these. However, there are five tests which may have potential. Two of these, static visual acuity and color vision, are already used by the Army in personnel selection and classification and should continue to be used. Three others, contrast sensitivity, dark focus and peripheral vision are not.

a. <u>Static visual acuity.</u> Static visual acuity, which is most typically measured by the familiar Snellen type letter charts, has long been used in personnel selection and classification. There is certainly ample research evidence that visual acuity is related to target detection and identification performance (e.g., Grossman & Whitehurst, 1976; Grossman & Whitehurst, 1979). However, further study of this measure is unlikely to be profitable. In his extensive review of the literature on air-to-ground target acquisition, Dan Jones (1974) cites 107 references dealing with visual acuity. However, he dismisses the subject in less than a page in his text--the reason being that personnel performing target acquisition duties in the military were screened on the basis of static visual acuity, so the range of acuity was so small it was found to be of little practical importance in applied or field studies. Nevertheless, personnel should still be screened to insure that they have, or can be corrected to have, normal visual acuity, both near and far.

b. <u>Color vision.</u> Normal color vision is absolutely essential for many military specialties. It is essential for superior target detection and identification performance. During World War II, it was thought that color defective personnel might be more effective in detecting camouflage. However, in a review of the literature on visual research conducted during World War II, it was concluded that color normals were superior to color defectives in detecting targets (Harvey, 1970). No recent literature could be located on this subject, as virtually all of the work done was accomplished with color normal individuals. It is concluded that AAWS-M gunners should be screened for normal color vision.

c. <u>Contrast sensitivity.</u> A measure of visual performance not currently used by the Army that appears to have good potential is contrast sensitivity. Recent evidence suggests that it is actually a better measure of visual acuity than static acuity as measured by the Snellen charts (Ginsburg, AGARD, 1980). Evidence that contrast sensitivity is highly related to aircraft detection has been presented in an Air Force study (Ginsburg, Easterly & Evans, 1983). In this effort, pilots were to detect an actual T-39 aircraft on an incoming leg. Variation due to search time was eliminated by placing the pilot observers at the end of an aircraft runway and having the T-39 fly in from the opposite end and directly toward and over the runway. Correlations between contrast sensitivity and range at detection ran as high as r = .93. Correlations for static visual acuity ran from r = -.56 to r = +.77 for 10 days of trials. Three of the correlations with static acuity were negative, and only two were significant and positive. Other evidence on the importance of contrast sensitivity in target detection ability comes from another Air Force study (Ginsburg, Evans, Sekular & Harp, 1982). In this study, pilots flew a simulator and were preparing for a landing. A MiG aircraft sitting on the runway was to be detected by the pilots. Again, pilots with superior contrast sensitivity detected the MiG at longer ranges. Essex (Kennedy, et al, 1984) researchers found a strong relationship between contrast sensitivity and aspect recognition of aircraft in a simulator.

Researchers for the Naval Aeromedical Research Laboratory found a correlation of r = .57 between detection ranges and one of the spatial frequencies measured in a test of contrast sensitivity (Jones, personal communication, 1985). Contrast sensitivity can be measured by several methods (Ginsburg, et al, 1983a).

There is also electronic equipment available for measuring dynamic contrast sensitivity. In this test, gratings of the same type move across a video monitor screen. It is recommended that both static and dynamic contrast sensitivity be evaluated as selection measures because of the potential they appear to have for predicting target detection performance.

    d.   <u>Dark focus</u>. Another visual characteristic which has received considerable attention recently is "dark focus." An individual's dark focus is the distance at which the eyes focus when they have nothing to focus on, such as when in complete darkness. In one study of 220 young people with normal vision, it was found that this resting focus of the eyes was normally distributed with a mean of 1.52 diopters, or approximately 65 cm (Leibowitz & Owens, 1978). Figure 2 shows this distribution (from Leibowitz, Owens, & Post, 1982).

The eyes tend toward this resting state in periods of low illumination such as at dusk. While there is no large body of data indicating that dark focus is related to target detection and identification performance, there are good indications (Kennedy, et al, 1984; Owens, 1984; Luria, 1980). Indirect evidence comes from studies in which corrections based on dark focus improved perceptual performance where clearly textured objects were not available for focusing. For example, one study compared the ability of eight observers to detect small low contrast targets with and without corrective lenses based on dark focus during a mild whiteout in the Antarctic (Luria, 1982). Detection performance for three men improved, and two others reported that the clarity of the targets improved. Another study reported that corrective lenses based on individual dark focus were universally preferred for night driving over corrective lenses prescribed in the normal manner (Leibowitz, Owens, & Post, 1982). A limited study conducted by the Air Force (Kennedy, et al, 1984) found that dark focus was related to aircraft aspect recognition. Owens (1984) reports on a study in which subjects detected a tiny dot superimposed on a uniform bright background both with and without dark focus corrections. All subjects showed the greatest sensitivity while wearing the corrective lenses, and the degree that performance improved depended on their dark focus. "When the threshold of visibility was related to nomograms that predict aircraft sighting ranges, increases in sighting range varied from 26% for a subject with a relatively distant dark-focus (1.0 D) to 316% for one with a relatively near dark-focus (2.0 D)" (Owens, 1984, pg 382). While the situation Owens used might be more relevant to air defenders, the possibility that dark focus would influence detection performance on the ground cannot be disregarded. Therefore, it is recommended that dark focus be evaluated as a selection tool for AAWS-M gunners. If it proves to be related, another interesting possibility suggests itself. Gunners could be issued corrective lenses based on individual dark focus for use during periods of low illumination, thereby improving their detection capability. Dark focus, or dark accommodation, can be measured both quickly and inexpensively (Berbaum, Kennedy, Williams & May 1985 (in preparation)).

    e.   <u>Peripheral vision</u>. There is very good evidence that peripheral vision is related to search performance (Smith, 1961; Johnson, 1965; Bloomfield & Smith, 1979). Good peripheral acuity would seem especially important for detecting motion in the periphery.

N= 220
Mean= 1.52
S.D.= 0.77

Focus in Darkness
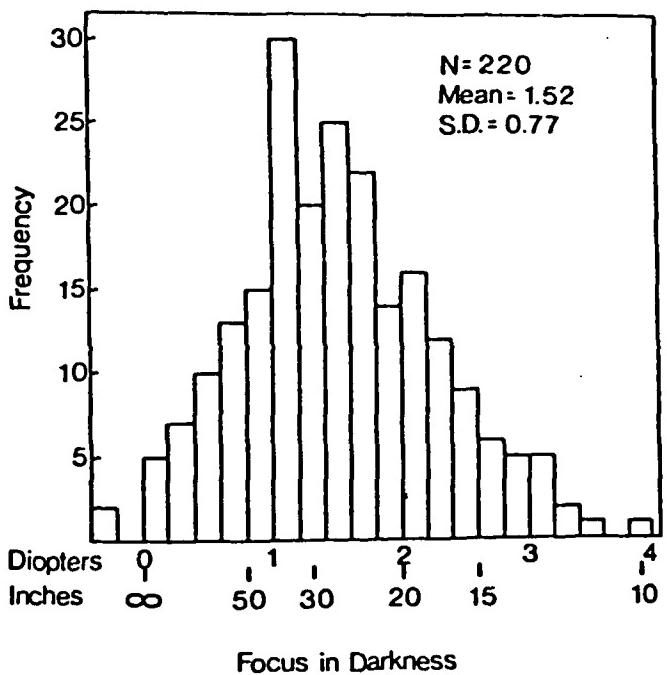
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Figure 2.   Frequency distributions of dark focus in diopters.

From: H. W. Leibowitz, D. A. Owens, & R. B. Post. Nighttime driving and visual degradation, Society of Automotive Engineers, 820414, 1982.

However, a major problem in testing for peripheral acuity is that the tests employed have typically shown fairly low test-retest reliabilities (Erickson and Burge, 1968; Jones [personal communication], 1985). For example, all four tests purported to measure peripheral acuity were discarded from the Naval Aeromedical Research Laboratory's Human Factors Vision Battery for this reason. One reason for these low reliabilities may have been the homogeneous population tested. All personnel were between the ages of 18 and 26 and had 20/20 vision. A search should be made to find or develop some more reliable measures of peripheral vision. Reliabilities may be improved, for example, by lengthening these tests or repeating them a number of times. Assuming a suitable measure or measures can be found, it is recommended that peripheral vision tests be included in a visual battery to be evaluated.

Certainly other visual tests might be included if the resources to evaluate them are available. There is, for example, a current project aimed at selecting a battery of visual tests with potential military applications (Berbaum, Kennedy, Williams, & May, 1985). The recommendations from the project report should be considered when the report is approved.

Motivation

There is one other approach to selection that we feel should be tried. This is "self-selection." Personnel who volunteer for a particular duty are more apt to be motivated than those who are levied into that duty, and therefore, are likely to be better learners and performers. For example, it was found that personnel selecting artillery as their branch of service were better performers than those who did not on most components of the forward area observers basic course (Mocharnuk, et al, 1979). This difference between volunteers and nonvolunteers is graphically illustrated in Figure 3. As can be seen, volunteers for air defense training had lower attrition rates at all aptitude levels (Kubala & Christensen, 1968). It is hypothesized that personnel who know what the job entails, and want that job, will do a better job. Therefore, it is suggested that if at all possible, that only volunteers be accepted for training.

At this point, it should be reemphasized that the effectiveness of any selection program is dependent upon the selection ratio. That is, it is dependent on the proportion of personnel that have to be selected from the available pool. The larger the proportion, the less effective selection will be regardless of how well the selection measures work. At this point, it is not even known what proportion of the available personnel pool might have some set of desired characteristics. Also, it is not known what other characteristics they might have that would make them excellent candidates for other jobs that will compete for these same personnel. Until these things are known, one cannot estimate the effectiveness of a selection program, even if some of the proposed measures prove to have great potential as selection devices for AAWS-M gunners.

TRAINING

The assumption has been made that training could improve target detection and identification performance. It follows, however, that it would have to be the "right kind" of training. The reason for this qualification is that an examination of the literature showed training to be effective in some cases, but not in others. The wide variety of

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Comparison of Attrition Rates Between Volunteers and Non-Volunteers
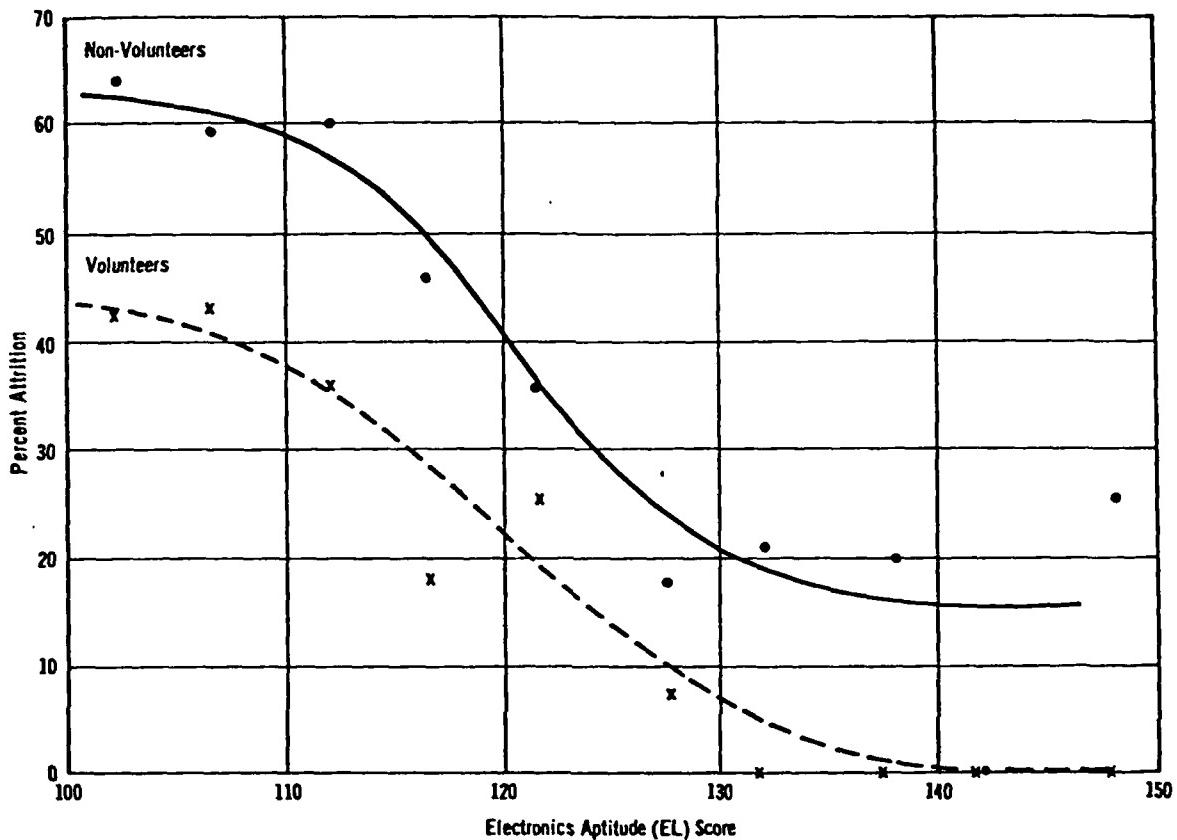
Figure 3.   Failure rates by aptitude scores for volunteers and non-volunteers.

From: A. L. Kubala & H. E. Christensen. The effects of group competition upon student performance (Technical Report 68-7), Alexandria, VA: Human Resources Research Organization, June 1968.

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situations in which training was evaluated makes it impossible to discern reasons for this inconsistency with any degree of certainty. Also, the actual training given was seldom fully described, so its real relevance could not be determined. Finally, it was often difficult to separate training from experience. In many cases at least a part of the training given consisted of practice on the task itself.

There seems to be ample evidence that training can improve detection and *identification performance because there is ample evidence that it has done so in the* past. An early Human Resources Research Organization (HumRRO) study (Wolff, et al, 1962) found that target detection training was most effective when a graded sequence of images was used. That is, when the detection task was gradually increased in difficulty. This study also found that training with 35mm slides transferred to a motion picture criterion test. An Air Force study evaluated an experimental training program for Forward Air Controllers (FACs). The training was based on a careful analysis of the job, and proved superior to the conventional training in both detection and identification performance of crewmen during actual flight tests (Taylor, Eschenbrenner & Valverde, 1970). Another Air Force study (Hansen, 1970) compared, among other things, two approaches to target identification training. One approach simply presented the targets and allowed the observers to pick their own cues for identification. The other approach made explicit the cues which should be used to identify and discriminate between targets. The group receiving explicit cue training performed better during a flight test over the target area. This same study also compared search training based on slides with training based on motion pictures. No differences in search performance of personnel based on type of training were observed during the flight test.

There has been considerable work done on the detection and identification training of photointerpreters. This work is relevant, as the AAWS-M gunner may well be searching a stationary scene much as the photointerpreter does. Results have been positive. For example, a four day course developed by the Air Force resulted in both improved accuracy and reduced interpretation time (McLeod, 1964). An ARI study showed that the use of an "Error Key" resulted in fewer errors in identifications. The Error Key essentially told the interpreter what not to look for, based on common errors made in the past by other interpreters (Martinek & Sadacca, 1965). In a summary of ARI research on photointerpretation, Powers and coworkers (Powers, et al, 1973) demonstrated that training in systematic search increased detections. Also, speed training increased speed approximately 200 percent without degradation of other performance.

The ARI Field Unit at Fort Hood has been involved in vehicle identification training for a number of years. Some of the more important findings were: (a) Tank crewmen typically averaged a little less than 10 percent correct identifications on a pretraining test consisting of two views of each of the 30 NATO and Warsaw Pact combat vehicles (Smith, et al. 1980). Warrant officer aviators, however, averaged nearly 60 percent correct on a similar test (Warnick & Kubala, 1979); (b) Training with motion sequences proved to be no more effective than training with static imagery presented on slides (Smith, et al, 1985); and (c) Learning rates varied markedly among individual soldiers (Smith & Heuckeroth, 1985, in preparation). This last point will be discussed a little later.

The research conducted at Fort Hood led to the development and fielding of a combat vehicle identification training program, usually referred to as the CVI Training Program. The program was designed primarily for training gunners engaged in combating armor vehicles, e.g., AAWS-M gunners. This program is modularized, with each module

designed to be completed within one class period. Each of the six modules trains the soldier to recognize and identify five NATO and Warsaw Pact combat vehicles. A seventh module is the end-of-training test, which includes each of the 30 different vehicles included in the training program. This is currently the Army's standard vehicle identification training program and is available Army-wide as GTA 17-2-9. A deck of playing size cards containing the same 30 vehicles has also been adopted by the Army and is recommended for sustainment training. It has been distributed as GTA 17-2-11.

As presently conceived, the AAWS-M will be equipped with a thermal imaging system, but the characteristics of the system are not yet fully determined. For this reason, detect' on and identification employing thermal imaging systems have not been previously discussed. No recent literature was available on this subject. However, ARI has had a great deal of experience in this area and has generated several training products. The Army has fielded an interim thermal combat vehicle identification training program developed by ARI. It is available as GTA 17-2-10. It is modularized like the basic CVI program. ARI has also very recently completed a videotape training program titled "Thermal Sight Contol Adjustment Program (An Orientation)." It was found that tank crewmen did not know how to use the controls on their thermal sights to maximize the likelihood of detecting and correctly recognizing and identifying potential targets. This tape demonstrates how to operate the controls to optimize performance and urges the crewmen to practice on their own sights what they have learned. Depending on the sight employed, it may be necessary to develop a similar presentation for AAWS-M gunners.

A promising area for training, but one which may require some research to develop, is the area of search strategy. An early HumRRO study compared four search techniques for aviators, and found one to be superior to the others in actual flight tests (Thomas & Caro, 1962). The best strategy had the aviator look out the side of the aircraft at 90 degrees to the flight path. He then swept his gaze inward toward the aircraft and outward toward the horizon. Since the aircraft was moving, the effect was to create a sawtooth search pattern. Another study evaluated the effects of practice, size of search sector, training in peripheral vision, and two scan patterns. The two scan strategies both improved detection performance, but findings for the other three variables were negative (Bloomfield & Smith, 1982). In research on aircraft detection employing simulation, it was found that systematic search patterns tended to improve search performance for most observers (Baldwin, 1973). However, the use of these search patterns tended to somewhat reduce the search effectiveness for observers with superior vision. The researcher hypothesized that individuals with superior vision developed their own effective strategies, and that forced deviations from these strategies reduced search effectiveness. Nevertheless, even for these observers, targets in some areas of the assigned sector were found more quickly, indicating that the entire area was more evenly scanned when employing one of the experimental strategies. Therefore, it appears from the literature that training in how and where to search will improve target detection performance.

Except for the one study which derived an optimum search strategy empircally, all the studies described in this brief review appeared to have one thing in common. The training was developed following a relatively detailed analysis of the tasks to be performed. For example, in developing the Combat Vehicle Identification Training Program, ARI researchers examined the identification task facing Army aviators with long range weapons systems. They found that the cues to identification at long ranges were quite different from those typically employed at short ranges. The location of

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searchlights, for example, was often taught as an identification cue, but the searchlights were not often visible at longer tactical ranges. By determining empirically what cues were available for each vehicle at long range, and concentrating the training on these cues, the researchers were able to train the aviators to nearly 100 percent correct identification performance at scaled ranges over 3000 meters. It is felt that the training for AAWS-M gunners must also be tailored specifically to their needs.

There is one more point that needs to be made concerning training. It was mentioned earlier that learning rates varied markedly among individuals. Figure 4 presents some data obtained by Smith and Heuckeroth (1985). The two groups represented by the two curves were formed on the basis of their identification scores following one training session with three modules from the CVI program. Notice that the curves stay well apart even after five additional training sessions. Also, notice that there would have been no way to separate the personnel on the basis of scores obtained prior to the first training session as all pretest scores were very low. There are two reasons for presenting this graph. One is to demonstrate that individuals learn at different rates. Therefore, the soldiers who formed this lower group would require considerably more training to bring them up to a 90 percent criterion, assuming they could be brought there at all. The second reason pertains to selection. The ARI group at Fort Hood feels that a single training session could possibly be used as a selection device. Those personnel with an aptitude for target identification could be selected on the basis of a cutting score following the first training sessions, and then further trained as AAWS-M gunners.

SUMMARY

In summary, some measures appear to have good potential for selecting AAWS-M gunners for detection and identification capabilities. In addition, the literature indicates that these measures should also be useful for selecting personnel for any weapons system which requires visual detection and identification of potential targets.

Measures of field dependence-independence is the only paper-and-pencil test that has demonstrated sufficient promise at this time for inclusion in an experimental test battery. Visual tests which are recommended for the battery are contrast sensitivity, dark focus, and a test of peripheral vision. Personnel from the US Army Aeromedical Research Laboratory have concluded that refractive status also may be important and so should be considered in constituting any experimental battery. However, even if some or all of these measures prove to be valid predictors of target detection and/or identification performance, the feasibility of a selection program will still depend on the selection ratio. That is, it will depend on the proportion of the personnel pool we would have to select. The smaller the proportion, the more effective the selection program would be. Finally, motivation is undoutedly important; and, ideally, only well informed volunteers should be accepted for training.

Results of research on the effectiveness of training for target detection skills have been mixed. Nevertheless, it is concluded that carefully tailored training will improve the target detection skills of AAWS-M gunners regardless of the feasibility of a selection program. It is further concluded that training for target identification skills has a positive impact, although learning rates vary considerably among individuals.

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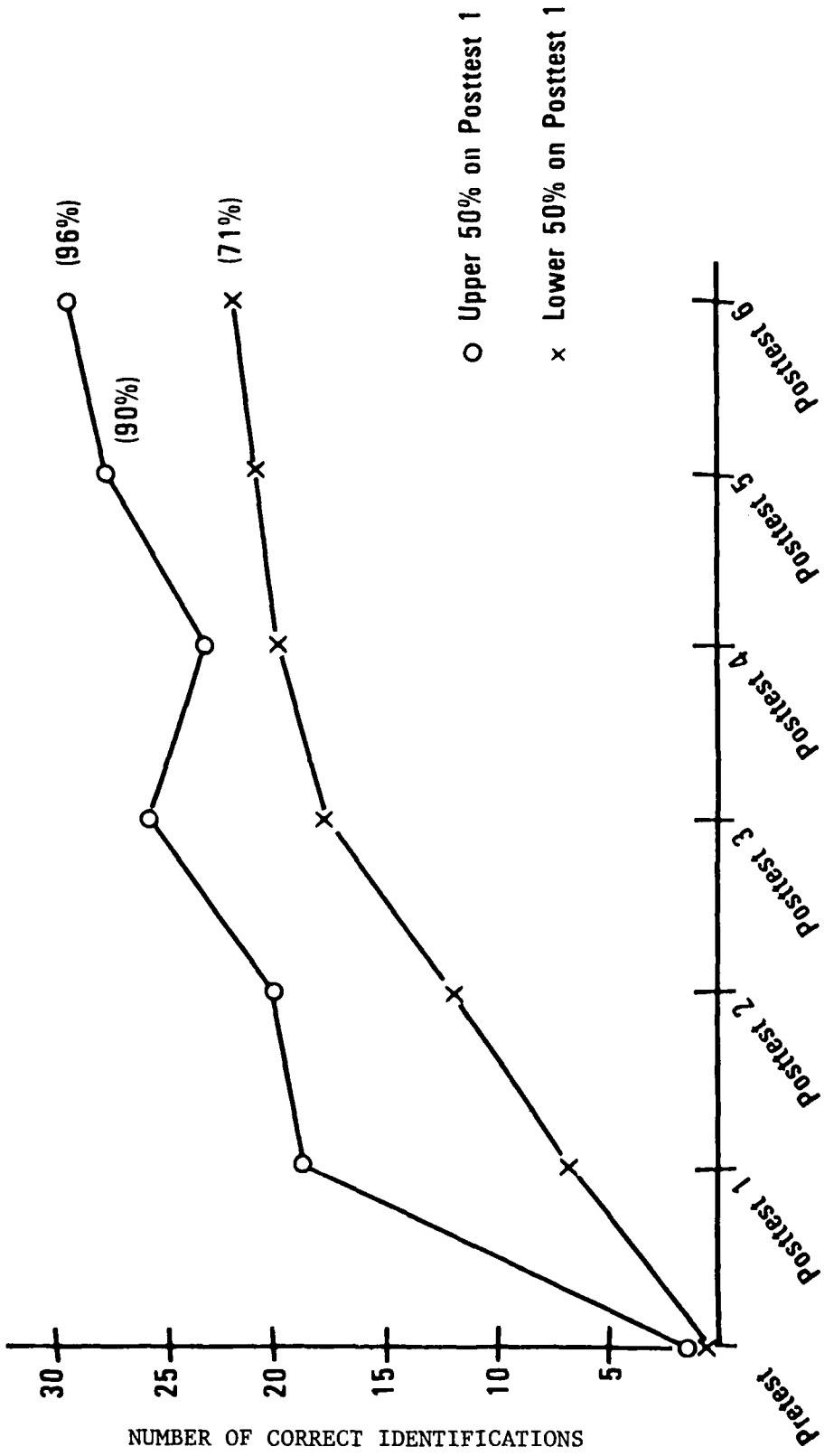
Figure 4. Vehicle identification learning rates for the groups based on initial scores.

Based on data from: N. D. Smith and O. H. Heuckeroth. Target acquisition and analysis training system: Guidelines for improving combat vehicle identification training program performance. Alexandria, VA: US Army Research Institute for the Behavioral and Social Sciences, 1985 (in review).

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